

# **Clewiston Phase I Test Report**

**Prepared By**



**October 16, 2001**

## Table of Contents

1	<a href="#">Introduction</a>	3
2	<a href="#">Testing Team</a>	3
3	<a href="#">Test Equipment</a>	3
3.1	<a href="#">Calibrated Test Set</a>	4
3.2	<a href="#">DBS Receivers</a>	6
3.3	<a href="#">MDS Receiver Set</a>	8
4	<a href="#">MDS Transmitter</a>	8
5	<a href="#">Test Methodology and Procedures</a>	9
6	<a href="#">Test Locations</a>	11
7	<a href="#">Data Processing</a>	12
7.1	<a href="#">Processing of DBS Data from the Spectrum Analyzer</a>	12
7.2	<a href="#">Processing of DBS Data from the SAT-9520</a>	13
7.3	<a href="#">Processing of MDS Data from the Spectrum Analyzer</a>	14
8	<a href="#">Test Results</a>	14
8.1	<a href="#">Discussion</a>	15
9	<a href="#">Conclusions</a>	17

## 1 Introduction

MDS America was granted an experimental license by the Federal Communications Commission (FCC) for the purpose of demonstrating and testing the HyperCable broadband wireless technology developed by MDS International. The MDS technology provides an approach to share the use of the 12.2-12.7 GHz band with Direct Broadcast Satellite (DBS) systems. On July 13, 2001, an extension of the original experimental license was granted.

This report provides the test data obtained during the test conducted in a rural environment, near Clewiston, Florida under the designated call sign WC2XPU. Field test were conducted during July 8 2001 to July 20 2001.

The primary objective for the test in Clewiston was to measure the presence and the extent of the MDS HyperCable signal interference into DBS satellite signals (DirecTV and EchoStar). The approach taken for this assessment was to measure and monitor the DBS signals in the presence of an MDS transmitter. This information was used to determine the Carrier-to-Noise-plus-Interference ( $C/(N+I)$ ). Tests were conducted at various receiving antenna sites and during a variety of atmospheric conditions<sup>1</sup>, within the test service area. Test sites included sites that appear to be worst-case interference conditions.

## 2 Testing Team

The field test for this project was conducted by Bahman Badipour, Sorin Kevorchian, and Bogdan Vasilescu all from LCC International. Peter Blond and Kirk Kirkpatrick from MDS America assisted LCC staff in the operation and manning the MDS transmitter site. The report preparation was done by Bahman Badipour with the help of Sorin Kevorchian.

## 3 Test Equipment

The test equipments are comprised of three sets, the calibrated test set, the DBS receiver set, and the MDS receiver set. In this section, a general description regarding these sets will be provided.

---

<sup>1</sup> Excluding rainy conditions

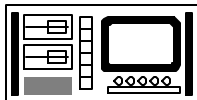
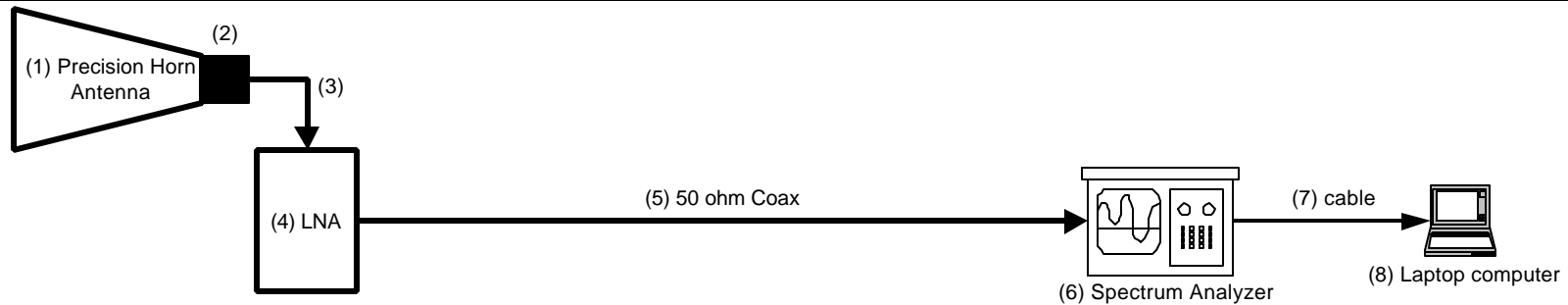
### 3.1 Calibrated Test Set

Figure 1 shows the measurement equipment and the reception system used in the calibrated test set. The receiver includes a precision horn antenna (1), a waveguide adaptor (2), an LNA (4), and related cables (3 and 5). Specific information regarding components and equipment model number are presented in Figure 1. The receiver was calibrated using the synthesizer (9) and the spectrum analyzer (6). Subsequent to calibration of the spectrum analyzer, the HP/83732B synthesizer was connected to the spectrum analyzer via (3), (4), and (5). Using the synthesizer a  $-50\text{dBm}$  signal was generated at various frequencies centered around 12.478 GHz and measured by the spectrum analyzer.

Table 1 shows the results of these measurements. A median value of 19 dB was used in the calculation of the total system gain. As noted in Figure 1 the horn antenna has a 23.5 dB gain over isotropic, thus the receiver set total gain is 42.5 dB.

Frequency (GHz)	Synthesizer Signal Level (dBm)	Spectrum Analyzer Level (dBm)	Gain (dB)
12.482	-50	-31.51	18.49
12.48	-50	-31.12	18.88
12.478	-50	30.77	19.23
12.476	-50	30.85	19.15
12.474	-50	30.91	19.09

Table 1 Test set receiver calibration



(9) Synthesizer

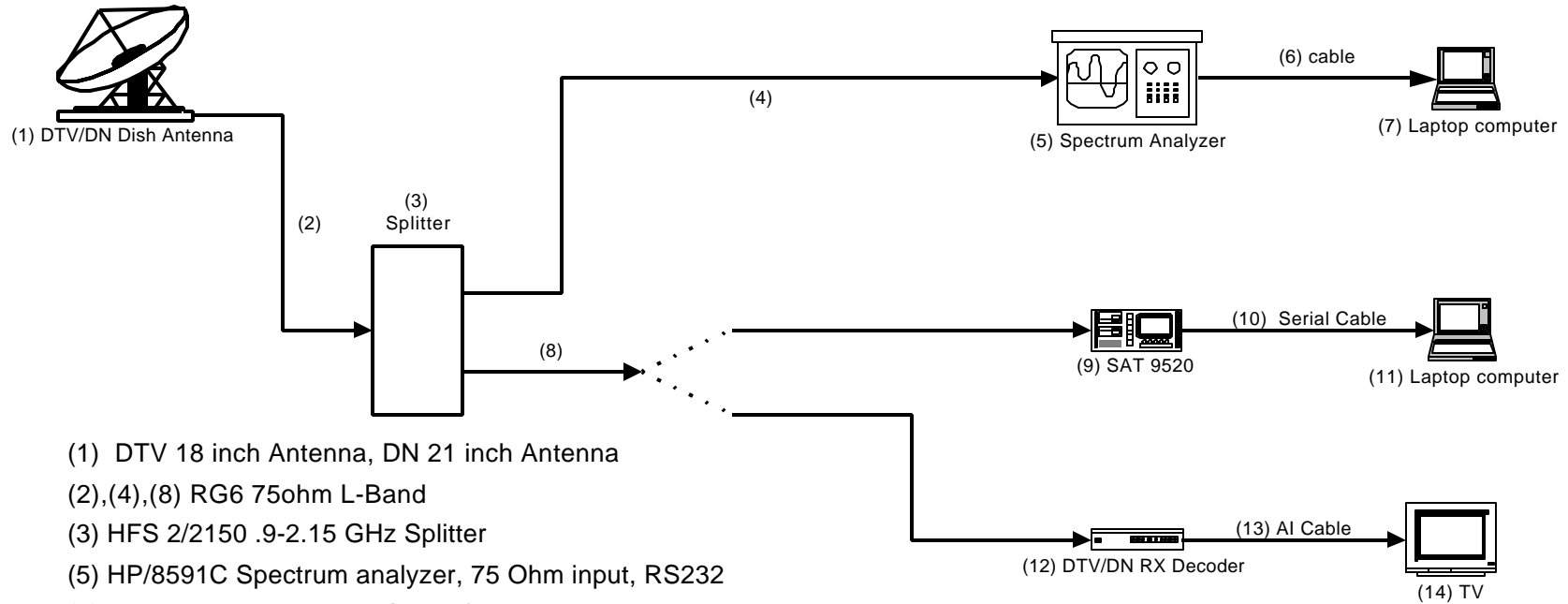
- (1) MI-12-12 Standard Gain Horn Antenna , 23.5 dB gain @ 12.5 GHz, Beamwidth- 10 Deg. H-Plane, 9 Deg. E-Plane
- (2) Narda 4609 Waveguide to SMA (F) coaxial adapters
- (3) Andrew LDF2P-50 SMA(M) 6ft, Attenuation: 0.94 dB @ 12.5 GHz
- (4) JCA1218-F01, 22 dB Min. Low Noise Amplifier
- (5) Andrew EFX2-50 SMA(M) 40ft, Attenuation: 6.5 dB @ 12.5 GHz
- (6) HP/E4407B 26.5 GHz Spectrum Analyzer with options: B75,A4H AXX, UK9
- (7) HP 24542U compatible Serial Cable
- (8) PC compatible Laptop computer with LCC's proprietary software
- (9) HP/83732B 20GHz Synthesizer, used for calibration

Figure 1 MDS receiver set

## 3.2 DBS Receivers

The two DBS systems tested were DirecTV (DTV) and Dish Network (DN). The receiver equipment for the DTV was model 4420RE and model PRO301-22B for DN. Each DBS receiving system includes a dish antenna and a combined receiver decoder (RX/DEC) Figure 2. The antenna used for the DTV signal reception was an eighteen inch dish with a Low Noise Block (LNB) converter that converted the Ku-band (12.2-12.7 GHz) satellite signal to L-band (0.950-1.450 GHz). Similarly, the antenna used for DN was a twenty-one inch dish with an LNB. The signal from the antenna was split using (3) to provide signals to the spectrum analyzer, SAT9520, and DBS RX/DEC.

The splitter had a D.C. pass from one of the outputs to the input, which allowed for the D.C. power passage to the LNB. The D.C. block output from the splitter (3) was directly connected to the spectrum analyzer (5) via (4). The D.C. pass output of the splitter was shared between the SAT-9520 and the DBS RX/DEC. During the data collection, SAT-9520 was connected to the D.C. pass output of the splitter via (8) and the power for the LNB was supplied by it. Similarly, during the picture observation, RX/DEC was connected to the D.C. pass output of the splitter. Further details regarding components and equipment model number are presented in Figure 2.



- (1) DTV 18 inch Antenna, DN 21 inch Antenna
- (2),(4),(8) RG6 75ohm L-Band
- (3) HFS 2/2150 .9-2.15 GHz Splitter
- (5) HP/8591C Spectrum analyzer, 75 Ohm input, RS232
- (6) HP 24542U compatible Serial Cable
- (7) PC compatible Laptop computer with LCC's proprietary software
- (9) Applied Instruments DBS Signal Level Meter Model SAT 9520
- (10) Applied Instruments SAT 9520 data transfer cable
- (11) PC compatible Laptop computer with Applied Instrument software
- (12) DTV/DN Receiver and Decoder
- (13) RCA Cable
- (14) Television set

Figure 2 DBS Receiver set

The spectrum analyzer was connected to a laptop (7) via a serial cable (6). During data collection, the spectrum analyzer data was collected by LCC's proprietary software and stored for later retrieval. Likewise, the SAT-9520 was connected to a laptop by an Applied Instrument (AI) serial cable (13) and data was collected by AI's software and stored for later retrieval.

### **3.3 MDS Receiver Set**

The MDS receiver set included a flat panel antenna with a total gain of 70 dB (20 dB antenna + 50 dB LNB) and an integrated spectrum analyzer/receiver decoder. The integrated spectrum analyzer/receiver decoder used for signal receiving, decoding, and observation was UNA OHM model EP507. A parabolic dish antenna with a total gain of 80 dB (30 dB antenna + 50 db LNB) was also used for locations that required higher gain antenna.

## **4 MDS Transmitter**

The MDS transmitter was installed on an existing United State Sugar telecommunications tower at a height of 28 meters (AGL), Figure 3.



Figure 3 MDS Transmitter installed on the US Sugar Telecommunication tower



The transmitter output power was set to 21 dBm Effective Isotropic Radiated Power (EIRP) with the 3 dB bandwidth of 27 MHz centered at 12.478 GHz. Figure 4 shows the MDS signal in reference to the Left Circularly (LC) polarized and Right Circularly (RC) polarized satellite signal.

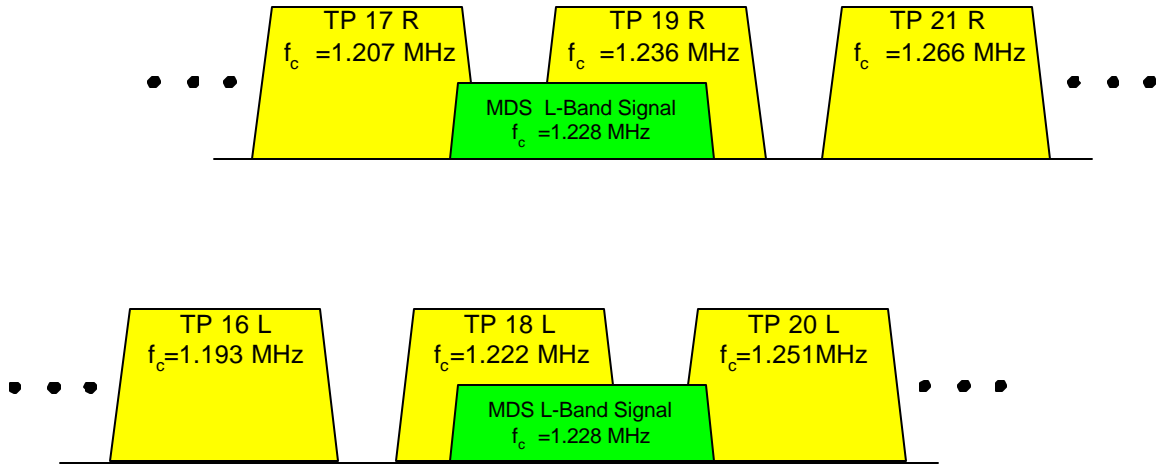


Figure 4 MDS signal in reference to the LC and RC polarized Satellite signal

The transmit antenna was pointed 110 degrees away from true North direction. The transmit polarization

The transmitter and related equipment are as follows:

- Custom Horn Antenna, 180°, H pol, 22 dB gain, Wave Guide losses 1 dB
- One Block ODU, Transmitter power 0 dBm
- One L band amplifier with variable attenuator
- One IDU, 10 MHz Clock reference, 50 meters of RG 214 cable

During testing, the MDS transmitter was periodically turned ON and OFF. The MDS transmitter site was manned so that any transmitter adjustments can be made as required by the tests.

## 5 Test Methodology and Procedures

The general test methodology was to measure and record changes in the DBS C/(N+I), IRD, and Bit Error Rate (BER) with the MDS transmitter ON and OFF. While the MDS transmitter was ON, a series of measurements were made and recorded. At each test site, the DBS receiver was set up to receive signal from one of the visible satellites. An MDS receiver was also set up to receive the MDS signal. Next, the MDS transmitter was turned OFF and again a series of measurements was performed.

Test receive sites were selected with the intention to represent random variation as well as the worst-case scenarios. These sites were chosen in different directions and distances from the transmitter, including sites very close to the MDS transmitter.

The measurement equipment, instrumentation, and DBS receivers were installed in a van for field transportation and deployment. A towable hydraulic lift device was also used as a receiving antenna platform and towed with the instrument van. The DBS antenna was mounted a heavy-duty tripod and fastened to one of the corners of the lift basket. Likewise, the calibrated test set antenna (Horn antenna) was mounted on a tripod and fastened to another corner of the lift basket. The MDS flat panel was secured directly to the perimeter bars of the lift basket. A 2500W motor-generator was also used as electrical power source.

The procedure for each test site was as follows:

1. Subsequent to the warm up period (30 minutes) of the spectrum analyzers, auto calibration was performed.
2. The calibrated EIRP test set antenna, the DBS antenna and/or the MDS receive antenna were positioned according to the test plan. A GPS reading was read and recorded.
3. The DBS satellite receiver was set to receive the satellite signal.
  - a. The DBS antenna was peaked using the IRD number from the SAT-9520.
  - b. Carrier power was measured using the HP/8591C spectrum analyzer and recorded.
  - c. The (C/N), IRD, and BER were read from the SAT-9520 and recorded.
4. The MDS Transmitter was turned ON and the MDS receiver was set to receive its signal.
  - a. The precision horn and/or MDS receive antenna was peaked using the HP/E4407B spectrum analyzer.
  - b. MDS Carrier power was measured using the HP/E4407B or UNA OHM and recorded.
5. With the MDS transmission system ON,
  - a. The satellite carrier power was measured using the HP/8591C spectrum analyzer and recorded.
  - b. The satellite (C/N), IRD, and BER were read from the SAT-9520 and recorded.

A site log was maintained with all the comments and notations about the sites and test conditions.

## 6 Test Locations

The interference effects of the MDS transmitter into the DBS systems were tested at 12 separate locations around the transmitter. Figure 5 displays the test locations with respect to the MDS transmitter. Note that, because of the reduced resolution in the figure, due to great distance between the MDS transmitter and site number 12, only eleven of the twelve test sites are show in this figure. The transmit antenna was placed on an existing communications tower at a height of 28 meters AGL. The distance between the test locations and the MDS transmitter site range from 77 m to 16.6 km as shown in Table 2. This table also provides the longitude, latitude, and the height of the receiving antennas.

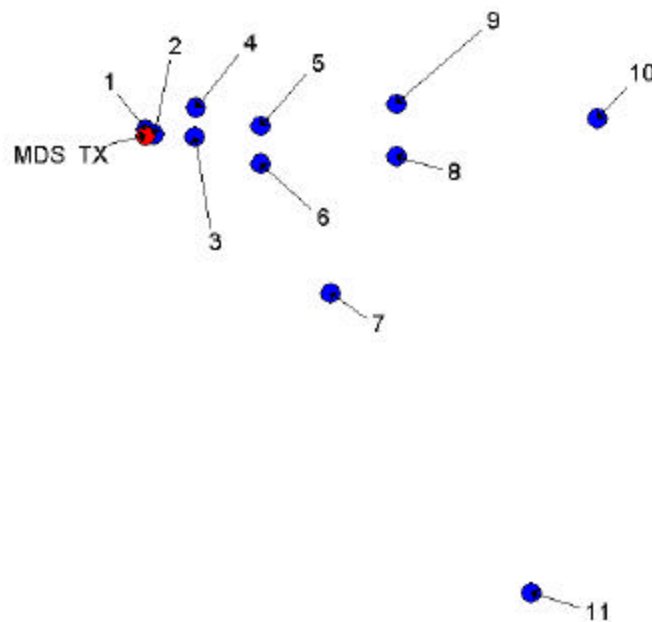


Figure 5 Receiver Test locations

Test Site	Longitude	Latitude	Height	Distance to MDS TX
1	80° 53' 57.78"	26° 42' 37.47"	2.68m	77.09m
2	80°53' 56.14"	26° 42' 35.64"	12.4m	108.3m
2_a	80° 53' 56.14"	26° 42' 35.64"	2.68m	108.3m
3	80° 53' 38.58"	26° 42' 34.63"	8.53m	0.5918km
4	80° 53' 38.7"	26° 42' 46.22"	6.95m	0.6981km
5	80° 53' 09.88"	26° 42' 38.98"	1.77m	1.39km
6	80° 53' 09.81"	26° 42' 24.12"	2.44m	1.427km
6_a	80° 53' 09.81"	26° 42' 24.12"	8.78m	1.427km
7	80° 52' 39.64"	26° 41' 33.93"	1.77m	2.914km
8	80° 52' 11.06"	26° 42' 27.25"	1.77m	3.018km
9	80° 52' 11.02"	26° 42' 47.55"	1.77m	3.035km
10	80° 50' 43.62"	26° 42' 41.94"	6.95m	5.43km
11	80° 51' 12"	26° 39' 37.08"	6.95m	7.2km
12	80° 44' 54.56"	26° 38' 48.26"	6.95m	16.6km

Table 2 Receiver test locations and height

## 7 Data Processing

### 7.1 Processing of DBS Data from the Spectrum Analyzer

The DBS output signal was measured using the HP8591C spectrum analyzer with a 75-Ohm input. The signal was collected using a laptop computer and the LCC's collection software. The software collected 401 data points after each spectrum analyzer (SA) sweep. The data was then recorded on the hard disk for later retrieval. The SA Resolution Bandwidth (RES BW) was set to one MHz for almost all readings. The SA Span, Sweep (SWP), RES BW, and Video Bandwidth (VID BW) were set in such a way to allow for calibrated read out. During the data processing, depending on record length, a number of sweeps were averaged. Thus, in the comparison plots to follow, the SA data represents the average power over the number of sweeps specified in the plots.

As part of data processing ( $C/N$ ) and ( $C/(N+I)$ ) calculation were performed on each sweep of data obtained from the SA. The calculation of ( $C/N$ ) was performed on the data obtained during the period when the MDS Transmitter was in the OFF state. In the following, the ( $C/N$ ) represents the ratio of the 3 dB power of the observed transponder to the averaged noise level immediately adjacent to the observed transponder region. The 3 dB power of the transponder was computed by integrating the region under the frequency range corresponding to the 3 dB points. Note that, the noise level includes the adjacent transponder interference.

Similarly, the calculation of ( $C/(N+I)$ ) was performed on the data obtained during the period when the MDS Transmitter was in the ON state. Note that, in general the ( $N+I$ ) level to left of the observed transponder may differ from the ( $N+I$ ) level to right of the transponder. However, due to the frequency positioning of the MDS signal (Figure 4) greater asymmetry may exist, depending on the strength of the MDS signal. Thus, both the right and the left ( $C/(N+I)$ ) were computed.

## 7.2 Processing of DBS Data from the SAT-9520

The DBS output signal was measured using the Applied Instruments (AI) SAT-9520 signal meter. The SAT-9520 measures the ( $C/N$ ), the Bit Error Rate (BER), and the IRD. Data was collected using a laptop computer and the AI's collection software. In addition, data from the SAT-9520 numeric display were read at approximately one-minute interval and recorded in a log. The AI's software collected data points approximately every 10 seconds. The data was then saved as an ASCII file on the hard disk for later retrieval.

During SAT-9520 Data Processing, every ASCII file was filtered and records that were poor, due to reset inadvertently generated by the acquisition software, were discarded. The ASCII files were then imported to EXCEL for further processing. During which, average, standard deviation, maximum/minimum values, and record count were computed for IRD, BER, and CNR fields. The same computations were performed on the readings recorded manually. The BER data obtained by means of the acquisition software proved to be a difficult process, due to the aforementioned reason. As such, in the following tables, the BER data presented are the ones recorded manually, which are limited to five readings per MDS transmitter state.

---

### 7.3 Processing of MDS Data from the Spectrum Analyzer

The MDS output signal was measured using the HP/E4407B SA with a 50-Ohm input. The signal was collected using a laptop computer and the LCC's collection software. The software collected 401 data points after each spectrum analyzer (SA) sweep. The data was then recorded on the hard disk for later retrieval. The data processing of MDS data is very similar to the processing of the DBS data. Again, in the plots of MDS signal to follow the SA data represents the power averaged over the number of sweeps specified in the plots.

## 8 Test Results

All data collected for this test were sampled and recorded digitally, which allowed for greater latitude for post-processing. For example, any portion of the data obtained from the spectrum analyzers can be zoomed in to examine the finer details of the signal. Additionally, the scales associated with the display of the signal power can be adjusted as required. Because of the way data has been collected (MDS ON/OFF state) for this test, it is possible to obtain ratio plots of DBS power with the MDS TX ON to DBS power with MDS TX OFF. This type of plots can be useful in identifying possible interference region particularly in the inter-transponder region.

The SA measurement plots and related images are shown in Figures. 6–107 for the test locations designated in Table 2 as sites 1-12. The sites are ranked according to distance from the MDS TX location.

In almost all measurements of the DBS signal, using the 8591C SA, following setting was used:

- SPAN 100MHz
- SWP 200 msec
- RES BW 1 MHz
- VID BW 300 kHz

The basic results presented for almost all transponders are a 30 MHz power spectrum plot, a 100 MHz power spectrum plot (centered on the observed transponder center frequency), and a DBS power ratio plot corresponding to the MDS ON/OFF state. The 30 MHz and the 100 MHz plots are comparison plots of the DBS power spectrum with the MDS TX ON and OFF. In addition, for almost all test sites, a power

spectrum plot of MDS HH<sup>2</sup> signal received by the calibrated test set is presented. An antenna configuration picture accompanies the results presented for each site.

Note that in some of the power spectrum plots, there is an almost constant bias in received power levels between the two observations of DBS signal. The frequency span of this nearly constant shift in the DBS received power levels is the entire 100 MHz span of the SA. A close examination of the weather conditions suggests a very close correlation between the change in weather conditions and the presence of this shift in received power levels. It is believed that this difference in received power levels is due to change in weather conditions between, and even during, the two DBS signal observations. As such, it should be understood that a simple constant difference of power levels, of wide frequency range, is not indicative of any interference. The weather conditions were extreme during the field test period with very fast change of cloud cover, temperature, and humidity. Such weather conditions are not uncommon in July for south-central Florida.

A summary of the DBS measurement results obtained from SAT-9520 and 8591C SA are shown in Table 3. This table provides the results from the SAT-9520 data processing, which includes: IRD average, BER average, and (C/N) average. The DBS (C/N) calculation from the SA data processing is also presented in this table for cross checking. As mentioned earlier both the left ((C/N)<sub>L</sub>) and the right ((C/N)<sub>R</sub>) signal-to-noise ratio are computed for the SA data.

Tables 4 and 5 provide more statistics on the data collected from the SAT-9520 and 8591C SA respectively. Table 6 presents the MDS measurement results collected from the HP/E4407B SA or UNA OHM model EP507. The (C/N) for the last three sites, shown in this table, were computed directly by UNA OHM model EP507.

## 8.1 Discussion

Figure 6 thru Figure 20 show the results from test location 1. In this location, signals from Echo Star satellite 110 (ES110) and ES119 were observed. Figure 6 and 8, respectively, show the 30 and 100 MHz power spectrum comparison of ES110 transponder (TP) 18 with respect to MDS TX ON/OFF state.

---

<sup>2</sup> Horizontal transmit - Horizontal receive

Examination of the two power spectrum plots show that there is very little change in the received signal that can be attributed to the MDS TX change of state. This is also supported in Figure 7, where the ON/OFF ratio is nearly 0 dB. Examination of Table 1 reveals that in fact the SAT-9520 results suggest the signal reception from TP 18 improved very slightly with the MDS transmitter ON. It is believed that change of weather may have slightly influenced the measurements. Site 1 is approximately 77 meters away from MDS TX (Figure 13) with the receive antenna at 2.68 m (AGL). A check of the remaining Figures and tabulated results for this site suggests that received signal quality from ES110 and ES119 was not changed by the presence of MDS signal.

Figure 21 thru Figure 28 show the results from test location 2. In this location, signal from DTV101 was observed. Figure 21 and 23, respectively, show the 30 and 100 MHz power spectrum comparison of DTV101 TP18 with respect to MDS TX ON/OFF state. Examination of the two power spectrum plots show that there is a change in the received signal in the inter-transponder region. This is also supported in Figure 22, where the ON/OFF ratio is approximately 1.5 dB in 1.236 GHz to 1.240 GHz region. It is believed that this change in the ON/OFF ratio is due to the MDS transmission. Examination of Table 1 reveals that there are changes in IRD, BER, and C/N results of SAT-9520, as well as, C/N results of the SA. Similar results are observed for the TP19, though at a lower scale. It should be noted that this location is about 100 meters from the MDS TX with the DBS antenna nearly at the center MDS TX beam. Expectedly, the worst-case interference was observed under this scenario.

Figure 29 thru Figure 36 show the results for test location 2a. This location is at the same distance from the MDS TX as location 2 however, at a lower height of 2.68 m (AGL). In this location, signal from DTV101 was observed. The results from the TP18 are particularly interesting given the very close proximity to the MDS TX. The weather conditions changed significantly during DBS data collection with the MDS TX in the OFF state. It is observed, from Table 1, that both IRD and C/N decreased with MDS TX OFF. This result suggests a base for relative impact of MDS transmission. For the TP 19, there are slight reductions in IRD and C/N.

Figure 37 thru Figure 42 show the results from test location 3. In this location, signal from DTV101 was observed. Figure 37 shows the 30 MHz power spectrum comparison of DTV101 TP18. No significant changes in the DBS signals can be observed. Figure 39 shows the 30 MHz power spectrum comparison of



---

DTV101 TP19. Examination of TP19 spectrum plots and Table 1 shows that there is a slight change in the received signal.

Figure 43 thru Figure 56 show the results from test location 4. In this location, signals from ES110 and ES119 were observed. Figure 43 and 47 show the 30 MHz power spectrum comparison of ES110 TP18 and ES110 TP19 respectively. No significant changes in the DBS signals can be observed in these Figures. Figure 51 and 54 show the 30 MHz power spectrum comparison of ES119 TP18 and ES110 TP19 respectively. Similar to ES110 results, no significant changes in the DBS signals can be observed in these Figures. However, Table 1 shows that there are slight changes in the received signal from ES119 TP 18 and TP19.

In sites 5 thru 12, there are no changes in the received DBS signals that can be attributed to the MDS transmission. For sites 10 thru 12, the MDS flat panel was used for reception of the MDS Transmission. Using the MDS parabolic dish antenna, the MDS signal was observed at a distance of 16.6 km.

## 9 Conclusions

This field test examined the issue of MDS to DBS interference in rural environment. Substantial amount of data were collected and processed. The DBS signals in the presence of MDS transmission were examined at twelve separate locations. Based on the analysis of the collected data, the MDS transmitter can very well co-exist with the DBS signal in this type of environment with a limited mitigation zone. The mitigation zone can be as small as 100 m around the transmitter.

					SAT-9520			8591C SA		Weather		
State	Date	Site	Satellite	Tp	IRD-avg	BER-avg	CNR-avg (dB)	CNR_L (dB)	CNR_R (dB)	Temp(F)	Sky	Notes
OFF	17-Jul	1	ES_110	18	89.02	2.54E-04	10.39	9.47	10.40	77.3	OC	Extreme variation in weather conditions, strong wind
ON	17-Jul	1	ES_110	18	89.19	3.28E-05	10.43	9.45	10.30	77.3	OC	
OFF	17-Jul	1	ES_110	19	98.39	3.60E-06	11.65	12.10	10.60	77.3	OC	
ON	17-Jul	1	ES_110	19	98.23	4.08E-06	11.63	12.10	10.60	77.3	OC	
OFF	17-Jul	1	ES_119	18	88.44	1.26E-04	10.35	10.30	10.60	91.0	OC	
ON	17-Jul	1	ES_119	18	87.69	2.14E-04	10.26	10.30	10.60	91.0	OC	
OFF	17-Jul	1	ES_119	19	96.50	8.76E-05	11.45	12.00	10.80	81.1	OC	A 10 degree F decrease in temperature
ON	17-Jul	1	ES_119	19	96.29	1.28E-04	11.43	11.80	10.70	91.0	OC	Strong wind, ready to rain
OFF	16-Jul	2	DTV_101	18	92.23	3.82E-05	10.79	8.32	8.73	81.1	PC	
ON	16-Jul	2	DTV_101	18	76.43	2.46E-04	9.67	8.39	7.24	81.1	PC	
OFF	16-Jul	2	DTV_101	19	95.71	1.96E-05	11.25	9.88	10.00	81.1	MC	
ON	16-Jul	2	DTV_101	19	82.21	1.82E-04	10.11	9.58	10.00	81.1	PC	
OFF	16-Jul	2a	DTV_101	18	95.94	2.00E-05	11.16	9.67	10.20	80.6	OC	Change in weather condition during the measurement
ON	16-Jul	2a	DTV_101	18	97.12	1.16E-05	11.29	10.70	11.20	83.6	PC	
OFF	16-Jul	2a	DTV_101	19	97.04	1.44E-05	11.40	10.30	10.30	83.6	PC	
ON	16-Jul	2a	DTV_101	19	92.20	4.84E-05	10.87	9.97	10.30	83.6	PC	
OFF	13-Jul	3	DTV_101	18	94.35	2.76E-05	10.96	9.21	9.53	81.3	CLR	Wind blowing harshly swinging the lift
ON	13-Jul	3	DTV_101	18	93.30	2.88E-05	10.87	9.19	9.43	81.3	CLR	
OFF	13-Jul	3	DTV_101	19	94.65	2.94E-05	11.08	9.41	9.69	81.3	CLR	Wind blowing harshly
ON	13-Jul	3	DTV_101	19	89.90	6.56E-05	10.66	9.03	9.75	81.3	CLR	Wind blowing harshly

Table 3 Measurement summary table

OFF	18-Jul	4	ES_110	18	95.72	2.32E-05	11.12	11.07	11.95	87.4	OC	
ON	18-Jul	4	ES_110	18	95.64	2.18E-05	11.11	11.03	11.89	87.4	OC	
OFF	18-Jul	4	ES_110	19	74.93	5.52E-03	9.39	7.21	7.35	87.4	PC	
ON	18-Jul	4	ES_110	19	73.09	6.18E-03	9.27	7.11	7.33	87.4	PC	
OFF	18-Jul	4	ES_119	18	86.94	3.32E-05	10.20	10.00	10.60	87.4	PC	Wind 5-10 mph
ON	18-Jul	4	ES_119	18	82.41	4.84E-04	9.86	10.11	10.48	87.4	CLR	Wind 5-10 mph
OFF	18-Jul	4	ES_119	19	96.46	7.64E-06	11.45	11.40	10.40	87.4	PC	Wind 5-10 mph
ON	18-Jul	4	ES_119	19	94.15	4.06E-04	11.18	11.10	10.40	87.4	CLR	Wind 5-10 mph
OFF	8-Jul	5	DTV_101	18	95.55	2.11E-05	11.06	10.20	10.40	85.1	CLR	
ON	8-Jul	5	DTV_101	18	95.47	2.46E-05	11.06	10.20	10.20	85.1	CLR	
OFF	12-Jul	6	DTV_101	18	95.59	2.28E-05	11.08	10.00	10.30	86.5	MC	
ON	12-Jul	6	DTV_101	18	94.49	2.28E-05	10.97	10.10	10.40	86.5	MC	
OFF	12-Jul	6a	DTV_101	18	95.60	2.32E-05	11.12	10.00	10.40	87.3	PC	SAT-9520 result are from the log
ON	12-Jul	6a	DTV_101	18	94.20	2.96E-05	11.00	10.00	10.30	87.3	PC	SAT-9520 result are from the log
OFF	10-Jul	7	DTV_101	18	95.34	3.78E-05	11.05	10.10	10.50	84.5	MC	
ON	10-Jul	7	DTV_101	18	95.24	2.68E-05	11.04	9.98	10.30	80.5	MC	Strong winds
OFF	10-Jul	7	DTV_101	19	93.19	3.94E-05	10.93	10.60	10.40	80.5	MC	
ON	10-Jul	7	DTV_101	19	92.57	4.30E-05	10.89	10.60	10.30	80.5	MC	
OFF	9-Jul	8	DTV_101	18	92.75	4.34E-05	10.84	9.55	9.91	90.2	MC	
ON	9-Jul	8	DTV_101	18	92.20	4.14E-05	10.77	9.48	9.76	90.2	MC	
OFF	9-Jul	8	DTV_101	19	90.77	5.72E-05	10.76	10.20	10.00	90.2	MC	
ON	9-Jul	8	DTV_101	19	91.70	5.00E-05	10.85	10.40	10.10	90.2	MC	

Table 3 continued

OFF	8-Jul	9	DTV_101	18	84.32	1.36E-04	10.19	8.65	8.93	88.0	MC	
-----	-------	---	---------	----	-------	----------	-------	------	------	------	----	--

ON	8-Jul	9	DTV_101	18	84.71	1.40E-04	10.20	8.63	8.73	84.5	MC	
OFF	8-Jul	9	DTV_101	19	91.00	5.24E-05	10.74	10.50	10.20	88.0	MC	SAT-9520 result are from the log
ON	8-Jul	9	DTV_101	19	90.60	5.66E-05	10.74	10.40	10.20	88.0	MC	SAT-9520 result are from the log
OFF	20-Jul	10	ES_119	18	82.99	4.48E-04	9.88	9.43	10.50	83.6	CLR	Partial cloudy then clear sky and an increase in humidity
ON	20-Jul	10	ES_119	18	82.34	5.44E-04	9.86	9.38	10.40	88.7	PC	
OFF	20-Jul	11	ES_119	18	80.76	7.50E-05	9.71	9.48	10.00	98.0	OC	Just after a short rain
ON	20-Jul	11	ES_119	18	81.74	5.52E-05	9.80	9.50	9.97	99.0	PC	Low wind, very hot 100F then completely overcast
OFF	20-Jul	11	ES_119	19	93.78	2.44E-05	11.09	11.30	10.30	82.4	OC	
ON	20-Jul	11	ES_119	19	92.90	2.52E-04	11.01	11.30	10.20	82.4	OC	
OFF	19-Jul	12	ES_110	19	91.83	3.60E-04	10.88	9.38	9.95	97.0	PC	
ON	19-Jul	12	ES_110	19	90.81	3.64E-04	10.76	9.14	9.71	93.8	OC	
CLR – Clear    MC – Mostly Cloudy    OC – Overcast    PC – Partly Cloudy												

Table 3 Continued